Why bad ideas are a good idea

Alan Dix[1], Tom Ormerod[2], Michael Twidale[3], Corina Sas[1], Paula Alexandra Gomes da Silva[1], Lorna McKnight[1, 2]

[1.] Computing/Infolab21
Lancaster University
Lancaster, LA1 4YR, UK
+44 1524 510319

[2.] Psychology Department
Lancaster University
Lancaster, LA1 4YF, UK
+44 1524 593164

[3.] GSLIS, University of Illinois at Urbana-Champaign, IL, USA
+1 217 265 0510

alan@hcibook.com, t.ormerod@lancaster.ac.uk, twidale@uiuc.edu,
c.sas@comp.lancs.ac.uk, palexa@gmail.com, l.mcknight@lancaster.ac.uk

ABSTRACT
What would happen if we wrote an Abstract that was the exact opposite of what the paper described? This is a bad idea, but it makes us think more carefully than usual about properties of Abstracts. This paper describes BadIdeas, a collection of techniques that uses 'bad' or 'silly' ideas to inspire creativity, explore design domains and teach critical thinking in interaction design. We describe the approach, some evidence, how it is performed in practice and experience in its use.

Keywords
Bad ideas, design fixation, creativity and innovation, critical thinking, lateral thinking

1. INTRODUCTION

1.1. Why Bad is the new Good
The focus of HCI has moved from evaluation and explanation (e.g. Card, Moran and Newell [5]) to design, a shift exemplified by ubiquitous, pervasive, mobile and distributed computing. After 20 years of relative stasis, we need to address radical new areas that not only support but *create* user experience. There are numerous techniques for creative thinking, such as de Bono's Lateral Thinking [2]. Also, there are examples of organisational cultures that make innovation possible (e.g., 3M Post-it notes). However, there is a dearth of reliable and engaging techniques to foster focussed innovation: Polya's work in mathematical problem solving [17] is a rare exception and Finke's [11] 'pre-inventive phase' for enhancing creativity has proved hard to replicate. Focused innovation is arguably an oxymoron: delivering reliable solutions to meet known goals is the antithesis of speculative invention, but we believe it is possible.

Individuals are strongly influenced by examples [13]. Generating ideas that are clearly influenced by the task environment has been called 'inadvertent plagiarism' [14], yet in the overwhelming majority of human activity, making use of prior information is a rational strategy. In the artefactual world of creative design, prior information constrains the generation of novel, unexpected, and ultimately copyrightable ideas. Concepts like brainstorming exist to encourage people to look beyond the current context in which they operate. However, even when people try to 'think outside the box', they are constrained by beliefs about what is sensible and rational, constraints which are in turn influenced by what they have experienced. In particular, having expectations about the 'goal' of problem solving can actively impair peoples' ability to discover novel paths to solution [19].

BadIdeas is an approach used deliberately by one of the authors for nearly ten years and accidentally by the others to encourage creative technical thinking. The technique generates silly or bad ideas initially to solve a problem rather than aiming directly for 'good' ideas. BadIdeas has been used in settings including individual use (undergraduate, postgraduate, doctoral and industrial), facilitated large groups and autonomous small groups. BadIdeas, we claim, encourages divergent thinking and more structured analysis of a problem. The former is obvious, the latter less so. Because a bad idea will be impossible, impractical or downright weird, it pulls the thinker outside the established design space. In practice, the majority of bad ideas are extreme variants of existing and potentially good ideas: for example, a bad idea for a novel car might be a car with no engine, which contrasts with a potentially good variant: a car that runs on solar power. As such, bad ideas allow the thinker to derive metrics with which to evaluate and extend all ideas.

Note that while most of the experiences describe din this paper have been on HCI and related courses, most of the examples we use are not HCI specific. This is because the interface 'bad ideas' tend to require too much explanation for a short example. Also note that as a convention in this paper the term 'BadIdeas' names the toolkit of techniques we are adopting whereas 'bad ideas' denotes the ideas themselves.

1.2. Empirical evidence for goodness in badness
Although we have theoretical arguments for BadIdeas, based on fundamental computational and cognitive knowledge, there is, we acknowledge, very little direct empirical evidence to motivate our thesis. However, an unpublished experiment provides some support. Participants attempted this 'insight' problem (c.f. Ormerod, et al [15]):

You have 9 balls. One of these balls weighs fractionally more than the others, though you cannot tell just by holding them. You are allowed only TWO weightings using a balance scale. How can you find the heavier ball?

The most common first attempt chosen by participants was 4 vs. 4, a move that is incorrect (the first weighing should be 3 vs. 3) but arises because individuals try to maximize the progress that each move makes towards solution. To our

surprise, 35% of participants chose a first attempt that was uneven (4 vs. 5, and even 1 vs. 8), moves that are essentially uninformative. Even more surprisingly, the percentage of participants who eventually solved the puzzle was higher with participants who started with an uneven attempt (68%) than with participants starting with an even weighing (47%). It seems as if getting off to a really bad start by making an irrational first attempt (and, with reflection, most of our participants recognized the inherent 'silliness' of an uneven weighing) aided participants in the longer run. We suggest that the 'bad idea' they began with acted to perturb their search of the problem space to deflect them away from seemingly 'rational' moves that make apparent progress but are ultimately incorrect.

2. METHOD: THE BADIDEAS TOOLKIT

2.1 First step

The first step is to think of a bad idea! The wording makes a difference: sometimes we use the term 'bad idea' and sometimes 'silly idea'. The latter avoids certain problems:

"*I've thought of a bad idea, but not sure if it is good enough*" (student, 2005)

However, the word 'bad' can seems less marked than 'silly', so we refer to 'bad ideas' and explain they can be silly bad ideas! The bad ideas that people find easiest to generate are simple contradictions: glass hammer, chocolate greenhouse, but given time they also produce Heath Robinson-style ideas The latter (named after the illustrator Heath Robinson's drawings of fantastic and superfluous mechanical creations that perform their function with an over-abundance of gears, pulleys etc) is where you make something 'work' by continually adding bits … rather like software!

2.2 Analysis: what, why and when not

BadIdeas comes with a collection of questions to examine the nature of the ideas and use them to inform understanding. This turns the divergent nature of the ideas themselves in a more convergent and analytic direction. Table 1 shows the initial set of what and why questions.

	THE BAD		THE GOOD
1	what is bad about this idea?	1	what is good about this idea?
2	why is this a bad thing?	2	why is this a good thing?
3	anything sharing this feature that is not bad?	3	anything sharing this feature that is not good?
4	if so what is the difference?	4	if so what is the difference?
5	is there a different context where this would be good?	5	is there a different context where this would be bad?

Table 1. Prompt questions for BadIdeas

Where the bad idea is a 'broken' variant of an existing thing, such as the engine-less car, there are natural 'good' things that are the benefits of the original item that were not broken. For example, the engineless car could still roll along the road with external propulsion. However, part of the rubric that goes with these prompts is to try and apply these to the obvious 'bad' feature: "what is good about not having an engine?" This examination of the positive aspects is one of the things that leads one to novel good ideas. The answer to the question about the engine-less car might be that the lack of an engine makes it lighter and cheaper ... and it doesn't use any petrol! A variant of prompt 4 is prompt 5: a thing that is bad in one context may be good in another. These 'good contexts' may be silly ones, such as a car on an elephant's back.

2.3 Turning things around

Thinking of 'good' things about bad ideas can sometimes be hard, but there are a number of prompts to help.

Back and forth

Questions 3 and 4 in Table 1 uncover converse properties: A caravan is like a car but has no engine, yet the lack of an engine is not bad for a caravan. As we examine why this is the case we begin to see positive things about not having an engine. Alternation between positive and negative is one of the central strategies in mathematical proof: when trying to prove a theorem, failures lead to attempts to construct counterexamples, and when these fail they suggest proof lemmas.

Change the context

The result of back-and-forth prompts is often a different context in which the bad idea is good and, this can also be a useful question to ask in its own right, hence prompt 5.

Role play

If participants are finding it hard to think of good things about bad ideas, they can imagine that the bad thing was designed this way deliberately… so why? As an extreme. imagine a world expert told you that the bad idea is the new paradigm for the field but dies suddenly before explaining why! The technique is especially useful when faced with a really bad system. The intention is not to show that bad things are actually good, but to uncover new dimensions and possibilities. When all else fails, imagine you are a used-car salesman selling the bad idea!

2.4 Making it good

The final part of the process is to turn the bad idea into a good one. This often happens of its own accord during prompting, but if not it is addressed as a separate stage. Where the bad idea is a 'broken' thing, like the engineless car, it is 'cheating' to make it good by mending it ("put an engine in"). However, it is valid and powerful to change the context of use. Again question 5 is good for this. The difference between this and the previous step is that we must produce

something that has the beginnings of pragmatics. For example, using a car without an engine as a greenhouse is good in making use of the car, but you couldn't imagine selling one. However, it might if there were some cachet attached to it, (e.g., a Rolls Royce greenhouse). If the environmental theme of the petrol-less car was deemed important one might imagine cars without engines into which you pack your holiday luggage and then dial in your destination. Moments later a roving robotic chassis picks your car shell up, and puts it on a train.

3. EXPERIENCES: DOING IT

3.1 Facilitated badness

The beginnings of using bad ideas as a structured approach to design were in lectures on research techniques given by the first author to undergraduate students at Huddersfield University embarking on their final year dissertations. Having discussed analytic methods to apply to existing situations (including a variant of Table 1) the issue of how to generate new research or practical ideas arose. Bad ideas were illustrated by the lecturer's own research publications ☺ (e.g. the Munchman interface [9]). The impact of these lectures was not evaluated, but the first indication of the BadIdeas effect was in facilitated sessions in small groups. The following excerpt taken from an exchange with a group of masters students at a guest lecture at Dublin Institute of Technology in 1998 exemplifies the approach:

Alan:	Can someone think of a really bad idea? (a pause followed by encouragement: " it can be anything as silly as you like")
Lecturer:	Inflatable dart board.
Alan:	Ok, what's bad about it?
A student:	It's full of air.
Alan:	A car tyre is full of air, is that bad?
A student:	No.
Alan:	Ok, so something else bad? (followed by long pause …)
Alan:	Ok, what's good about it?
A student:	It floats.
Another:	You can deflate it and pack it away.
Alan;	Ok, so let's think again what's bad (eventually, with more encouragement …)
A student:	The darts would burst it.
Alan:	Can we make it good… but still must be inflatable
Another:	Those sticky ends (discussion here … velcro, suckers, etc.)

We realised at this point we had the makings of a product: an inflatable dartboard that would pack up into your suitcase, to go to Ibiza, when you wake at 3pm, you go to the pool, blow it up and throw darts as it floats on the water. Extensive prompts were needed to avoid 'bad' points that were not the crucial bad thing. Similar experiences led directly to the development of prompt 3 in Table 1. The difficulty in saying "darts would burst it" seems particularly odd and the reason may be because the lecturer contributed the original bad idea, and so there was some reluctance to say the obvious (perhaps the students felt the distinguished visiting professor was expecting something more profound!). The criticality of the social situation is something that has recurred in this work. In more recent uses the introductory rubric and other means have been used to try and reduce social barriers. This issue arises in brainstorming where some early meeting support systems forced anonymous contributions.

3.2 Competitive badness

The first non-facilitated use of BadIdeas was at an away-day of the Computing Dept. at Lancaster (PhD students, researchers, administrators and academics). Participants were assigned to groups before the event and were asked to create a list of bad ideas that were allocated to other groups to turn into good ideas. The inflatable dartboard was given as a paradigmatic example and, perhaps not surprisingly, the majority of the suggestions were of this mutually contradictory kind including the glass hammer mentioned previously, see-through Venetian blinds and a chocolate blow torch. The only real exception was a Heath Robinson style contraption to protect wildebeest from predators at waterholes.

The teams were given an earlier version of the Table 1 prompts and about 40 minutes to address prompts, create good ideas and write slides to present them back to the group. Although it had been expected that some facilitation would be required, in fact the teams proceeded independently, including rejecting 'cheat' solutions (such as using the glass hammer for an ornament). One example of the output was transparent Venetian blind. The final design was to put LCD material into the slats of the blind, which could then be seen through, show images or be blacked out completely.

The way the form of the bad ideas followed from the suggestion emphasises the way that even such a clearly divergent approach can be constrained. However, arbitrary constraints are also known to be useful in creativity and certainly this form of bad idea has proved particularly fruitful.

The success of the approach is also sensitive to the group and social situation. At a 'Headstart' week for gifted sixth form school students (approx 17-18 years), a BadIdeas session was run one evening with a very similar format to the above. Whilst still successful in terms of enjoyment and creative result, it was obvious that the students struggled with the notion that an activity could be both silly and serious and also some groups were inclined to interpret the 'rules' too literally. The chocolate greenhouse group in particular found it hard to get past 'but it would melt' and some facilitation was needed to suggest that melting things might be useful sometimes.

3.3 Goal-oriented badness

Whilst the computing group tended to produce final good ideas that had some computational element to them, all the above were set in a very open context – any bad ideas and any way to make them good. The technique has also been used in more 'goal oriented' fashion with students of the User System Interaction (USI) course at Technical University of Eindhoven. Here the format has been slower paced with design projects starting with BadIdeas extending through a whole week. The students have been given more directed briefs bad ideas for "collaborative device for children" in one year and "non-talk mobile phone use" in a second year.

The slower pace led to more Heath Robinson ideas … an initial bad concept with a series of increasingly arcane fixes, fixes to fixes, etc. Heath Robinson ideas need a slightly different approach in addition to the Table 1 prompts as there are, in a way, just too many bad ideas in them! The students needed to be encouraged to take the 'fixes' one by one and analyse them largely in isolation. They were disinclined to simply take one of the 'fixes' and run with it as inspiration, preferring to keep with the whole concept.

It was noticeable too that the first year students produced more divergent initial ideas. Whilst this may be due simply to a different group of students, there were 5 teams each year and the effect was consistent. The explanation may be partly due to the different briefs. A "collaborative device for children" does not have any 'obvious' standard answer, whereas the very mention of 'mobile phone' in the second brief led to some fixation. Interestingly this was countered by requesting that teams produced bad ideas for the other teams to use (as described in the away day above). The students produced far more wild ideas when they knew another team had to deal with it!

3.3 Focussed badness

Given some of the possible difficulties with the concept of 'bad ideas', a more modest approach was tried at University of Illinois (UIUC). In this case, an overall design task had already been assigned, and students were exploring ideas within its constraints. One task was the development of applications for interactive public displays of various sizes situated in a University building. Within this context, students seemed to be comfortable in switching between sensible and silly ideas, often by taking one and tweaking it into the other. The introduction of a bad idea was always clearly flagged as such by the student proposing it. This activity was combined with elements of the use of personas, scenarios and bodystorming [16]. For example, in acting out a chance meeting between two colleagues near to a display, a good idea of using the display as a resource to share data was mutated into a bad idea of private information being automatically called up that could easily be seen by other passers by. Similarly a reminder facility, based on detecting the presence of a particular individual, and reminding them of a task to do that was temporally and geographically appropriate, like to go to a nearby office and collect an item, was turned into a bad idea by a public reminder of an embarrassing 'to do' item, such as an overdue piece of coursework, or a constant nagging by the system of things yet to be done. Ideas of other inappropriate, annoying or irritating items to put on public displays included personal information, certain kinds of advertising, out of date or incorrect information, and overly distracting images such as flashing lights, very rapidly moving images, or tantalizing pieces of information that disappeared too quickly never to return. These are all very modest variants compared to the more radically innovative uses of bad ideas outlined above. However they can still help in exploring a design space and in helping students become comfortable with the technique.

4. RELATED TECHNIQUES

There is a large literature on creativity and ways to be more creative. In the literature the term creativity is sometimes applied to artistic, technical or problem-solving creativity. In the latter case there is usually some level of bias. For example, Csikszentmihalyi's study of creativity is based on interviews with 'creative' people of all kinds; however his analysis is focused on societally established criteria and coloured by aesthetic notions [8].

In this paper we focus on technical creativity, or perhaps innovation and problem solving, However, when looking at, certainly more experimental, arts, the techniques are not so different. An art piece or installation may aim to provoke an audience reaction to a controversial subject by in some way violating accepted norms – that is, by being 'bad'. For example, a recent exhibition at UIUC entitled "Balance and Power: Performance and Surveillance in Video Art" explored contemporary concerns about security cameras using video art pieces such as clandestine videos of bus passengers. Part of the aim of such pieces is to provoke discussion in the viewers of how video surveillance is, might, and should be used outside the art gallery in everyday life.

One of the things that bad ideas do is to help you understand something by breaking it. This is certainly a theme in the artistic imagination. The two can come together, for example the schizophrenic cyborg is a performance arts piece designed specifically to explore issues of identity and third-party interactions in cyborg experience [18]. Berkun [1] notes the importance of having many ideas, including bad ones, as part of the design process and as a way of avoiding an obsession with the single right answer.

The first stage of BadIdeas exploring the design space is reminiscent of forms of brainstorming and de Bono's lateral thinking. As noted brainstorming tries to allow judgement-free posting of ideas, however, still the ideas are usually expected to be in some way pertinent – good in some way if not perfect in all ways. De Bono talks about the 'green hat' of creativity freewheeling with little criticism of ideas [3]. Bad ideas stand out in not only being non-judgemental but in explicitly encouraging things which are the 'wrong' side of the line of good judgement – anti-judgemental!

As well as a tool of synthesis, in idea creation, BadIdeas can also be used as a tool of analysis. We have explored this somewhat in the area of scenario-based design [6]. In computer systems design, scenarios (and also personas [7]), are typically used in a rather utopian manner to serve as illustrations of the benefits of an envisaged system, and so to justify allocating resources to constructing it. However, just as good ideas can be productively tweaked to create bad ideas as starting points for even better ideas, so a utopian scenario can be tweaked, by asking 'what can go wrong?'. Here the aim is to challenge the envisaged optimistic smooth interaction in order to see if the proposed design is robust enough to cope with the petty shocks of reality. A range of plausible failures are proposed. If it is possible to create a reasonable sounding description of how real people using the system would somehow cope, the designers can be somewhat more confident that their design is not so brittle that it can only operate in utopian conditions. This 'scenario tweaking' is in part inspired by the cognitive walkthrough method [20], a rapid HCI analytic technique that involves careful consideration of the knowledge a user would need to successfully complete a use sequence with a device, and again a consideration of what might happen under certain failure conditions of this use scenario. The method also draws on dystopian science fiction traditions, perhaps best typified by books and movies of the 1970s and 1980s, that stand in marked contrast to much science fiction of the 1950s and 1960s that presented more of a technological utopian vision.

An additional heuristic we have suggested alongside BadIdeas is random metaphors: declare that your domain or some thing in it is like the randomly chosen metaphor, e.g. "MacOSX is like a termite mound". You then have to justify the metaphor … Lots of small things that add up to a whole? Why not a Lego model then, why termites? Perhaps organic rather than mechanistic? The idea again is to force you to think in different ways about familiar things.

This is akin to the more analytic side of the BadIdeas technique where the bad idea is critiqued almost as if it had been a candidate good idea in the first place seeking out the bad and good. Again these are reminiscent of de Bono's optimistic 'yellow hat' and pessimistic 'black hat' looking for the good and bad, but with a more analytic twist in that the prompt questions 3 to 5 seek to create disjunctions and explore the structure of the design space at a larger level.

Several writers discuss creativity in terms of left/right brain distinctions. Some associate creative people with the more intuitive, associative, spatial (and optimistic) right brain rather than the rational, linear, linguistic (and pessimistic) left brain (e.g. Zdenek, cited in [4]). However, Csikszentmihalyi [8] claims, that creative people have great potential in both sides, related with the process of holding and dealing with both sides instead of enhancing one or the other. From another perspective and considering the creative process, Gabora [12] believes that creativity is related with both conceptual fluidity and focus or control. Sometimes, fluidity of thought is important, especially when we are looking for potential solutions. These thoughts often happen randomly. Although, at a certain moment, focus is critical. At some point an idea detach from others and the individual has to focus on the creative idea and develop it.

BadIdeas precisely encourages a movement between divergent and convergent thinking … perhaps right brain / left brain, but certainly regarding the two as intimately linked. In previous talks this has sometimes been referred to as "Professor Alan's formula for creativity" (sic) [10]

$$\text{structure} + \text{diversity} \Rightarrow \text{innovation}$$

Whilst some of the aspects of BadIdeas can be 'done' on your own – each of the experiences described above has been social. Indeed, irrespective of the more cognitive or structural strengths of BadIdeas, intense and often playful time limited social engagement are often found to be a stimulus for creativity in itself: for example in hack fests. Another technique used several times at Lancaster University has been Scrapheap Challenge events, based on the TV series run in several countries, where teams have to competitively create new designs or working prototypes within a single day.

6. CONCLUSIONS

BadIdeas has been adopted to *train* critical thinking, to *explore* the design space and to *understand* the design space. All three depend on the way that bad ideas *reduce personal commitment*. By this we do not mean that people using BadIdeas do not get committed to the process. Quite the contrary, participants in BadIdeas sessions are invariably very engaged with the process. This is more about emotional attachment and hence defensiveness about the idea. With a good idea the greater investment to the idea makes it harder to ask the "what is bad about it" questions ... "of course nothing is bad about it – it is a good idea and it is *my* good idea!" Where defects are seen in good ideas there is a tendency to either justify them or to look for an instant fix. In contrast bad ideas reduce commitment so that people are more likely to think 'out of the box', they don't have to defend their choices … and their choices don't have to achieve anything!

Table 1 provides the same questions one should ask about a good idea or about an existing system that one was planning to change or use. However, when faced with an existing system that is in some way 'bad' many people find it hard to either articulate exactly what is bad or to realise what is good about it. The former makes it hard to fix problems, the latter makes it likely you will cause new ones! The situation is even worse with your own ideas, where as we noted the high level of personal commitment makes it hard to be critical. The nature of bad ideas and their playfulness appears to make it easier for people to apply critical 'why' questions. Even then it is not without problems, as the inflatable dartboard example showed, but certainly easier than when it is *my* good idea I am defending. The hope is, although we have no direct evidence, that by applying this critical analysis to bad ideas students will be better able to apply it elsewhere.

The process of asking the prompt questions forces you to articulate dimensions, properties and criteria of the design space. The creation of bad variants of good designs involves the violation of goals or constraints within the design space,

that exist but may be implicit. This violation makes goals and constraints explicit and more open to exploration. For the inflatable dart board, looking at other things that are inflatable and good forces us to distinguish what it is about inflatability that can be good (ability to pack small, floating) from those that are bad (punctured by sharp objects). With this understanding we are not simply fixing the bad ideas, but moving with greater knowledge amongst design options. For example, we may realise that a cork dartboard would float too and explore what it suggests to us … throwing pointed darts into a crowded swimming pool would not be a good thing, but perhaps floating drinks trays might.

This kind of analysis is part of a related set of techniques that have been taught both alongside and independently of BadIdeas. In talks in this area creativity steps have been likened to ant steps or flea jumps [10]: the ant moves by very small steps following trails of scents, whereas the flea jumps pretty much wildly. If the flea kept crawling on the carpet it would never find the dog, but most flea jumps get it nowhere. Convergent thinking takes you gradually along like ant steps, whereas divergent thinking takes you into the unknown ... but it is typically nowhere worth going! Understanding the design space makes you more like an explorer with aerial photographs: you are still exploring on the ground, but you understand the land you are in. This allows large steps, but ones more likely to end up in useful places.

ACKNOWLEDGMENTS

Many thanks to all of those who have been guinea pigs for this work including students at Huddersfield University, Staffordshire University and DIT Dublin, who (some years ago!) were the first to experience these techniques; the USI generations 2003–2005 and 2004–2006 at TU/e Eindhoven; the participants at the Lancaster Headstart 2005 programme; various members of Computing at Lancaster; and recent students on the MSc and MRes programmes in Computing and Psychology at Lancaster and MSc students in Library and Information Science at UIUC.

REFERENCES

1. Berkun, S. (2000). Why good design comes from bad design. http://www.scottberkun.com/essays/essay08.htm
2. de Bono, E. (1970). *Lateral thinking: a textbook of creativity*. Ward Lock.
3. de Bono, E. (1985). *Six Thinking Hats*. Little, Brown and Company.
4. Bullinger, H.-J., F. Müller-Spahn, et al. (1996). Encouraging Creativity - Support of Mental Processes by Virtual Experience. *Virtual Reality World* 1996.
5. Card, S. K., Moran, J., and Newell, A. (1983). *The psychology of human computer interaction*. Hillsdale N.J.: Erlbaum.
6. Carroll, J. (2000) *Making Use*. MIT Press.
7. Cooper, A. (1999). *The Inmates are Running the Asylum: Why High Tech Products Drive Us Crazy and How to Restore Sanity*. Sams.
8. Csikszentmihalyi, M. (1997). *Creativity: Flow and the Psychology of Discovery an Invention*. USA, First HarperPerennial.
9. Dix, A. (1987). The myth of the infinitely fast machine, in *People and Computers III - Proceedings of HCI'87*, D. Diaper & R. Winder (eds). Cambridge University Press. pp. 215-228.
10. Dix, A. (2002). Teaching Innovation, (keynote) *Excellence in Education and Training Convention*, Singapore 2002. http://www.hcibook.com/alan/talks/singapore2002/
11. Finke, R. (1990). *Creative Imagery. Discoveries and Inventions in Visualisation*. Hove and London: LEA.
12. Gabora, L. (2002). Cognitive mechanisms underlying the creative process. *Fourth International Conference on Creativity and Cognition*, Loughborough University, UK. 126-133.
13. Jansson, D., and Smith, S. (1991). Design fixation. *Design Studies, 12*, 3-11.
14. Marsh, R., Ward, T., and Landau, J. (1999). The inadvertent use of prior knowledge in a generative cognitive task. *Memory & Cognition, 27*(1), 94-105.
15. Ormerod, T., MacGregor, J., and Chronicle, E. (2002). Dynamics and constraints in insight problem solving. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28*(4), 791-799.
16. Oulasvirta, A., Kurvinen, E., and Kankainen, T. (2003). Understanding contexts by being there: case studies in bodystorming. *Personal and Ubiquitous Computing*, 7(2) 125-134.
17. Polya, G. (1957). *How to Solve It*, 2nd ed., Princeton University Press
18. Sheridan, J., Dix, A., Bayliss, A., and Lock, S. (2004). Understanding Interaction in Ubiquitous Guerrilla Performances in Playful Arenas, in *People and Computers XVIII-Design for Life: Proceedings of HCI 2004*. S. Fincher, P. Markopolous, D. Moore, & R. Ruddle (eds.). Springer-Verlag, pp 3-18.
19. Sweller, J. (1983). Control mechanisms in problem solving. *Memory & Cognition, 11*(1), 32-40.
20. Wharton, C., Rieman, J., Lewis, C. and Polson, P. (1994). The cognitive walkthrough method: a practitioner's guide, in *Usability Inspection Methods*. J. Nielsen & R. Mack (eds). John Wiley & Sons. pp 105-125